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Longitudinal Effects of Psychological Resources on Chronic Conditions: The Mediating Roles of Allostatic Load and Health Behaviors

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Longitudinal Effects of Psychological Resources on Chronic Conditions: The Mediating Roles of Allostatic Load and Health Behaviors

by

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Dedication

This thesis is dedicated to my parents for their endless support, love and encouragement.

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Abstract

Longitudinal Effects of Psychological Resources on Chronic Conditions: The Mediating Roles of Allostatic Load and Health Behaviors

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Objectives: The purpose of this study is to investigate the longitudinal effects of psychological resources on chronic conditions, and the mediating roles of allostatic load and health behaviors. Methods: Participants (N=850) from the Midlife in the United States (MIDUS) cohort completed psychological resources surveys, biomarker collection, and a health assessment over the course of 10 years. Path analysis was conducted to examine the direct and indirect effects of psychological resources (baseline) on chronic conditions (7-10 years follow-up). Results: Psychological resources were negatively associated with chronic conditions directly ($b = -.219$, $p < 0.001$) and indirectly through allostatic load ($b = -.019$, $p < 0.05$), but not through health behaviors ($b = -.008$, $p = 0.093$). Discussion: This study highlights the importance of psychological resources and their positive influence on chronic conditions. Future research should examine additional potential mechanisms by which psychological resources have beneficial effects on chronic conditions.

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Introduction

The prevalence of chronic health conditions among adults in the United States is increasing, and is compounded by the rising incidence of multiple chronic conditions (Ward, Schiller, & Goodman, 2014). Chronic conditions are defined as "conditions that last a year or more and require ongoing medical attention and/or limit activities of daily living," and include a wide range of physical and mental health problems (Parekh, Goodman, Gordon, & Koh, 2011, p. 461). Some of the most prevalent chronic conditions are hypertension, heart disease, depression, diabetes, and arthritis (Centers for Disease Control, 2012). As of 2012, 50 percent of adults had at least one chronic condition, 25 percent have two or more chronic conditions, and 23 percent of adults aged 65 and older had five or more chronic conditions (Chevarley, 2012; Ward et al., 2014).

The high prevalence of chronic conditions is a serious problem given its negative impact on public health and the economy. Seven of the top ten causes of death in the United States are due to chronic conditions, and multiple chronic conditions account for nearly 70 percent of the nation's total health care expenditures (Gerteis et al., 2014). Chronic conditions are also associated with a lower quality of life, higher risk of physical disabilities and premature death, and an increased financial burden on both individuals and the economy (Vancampfort, Stubbs, & Koyanagi, 2017). Considering the significant physical, psychological and economic consequences associated with chronic conditions, it is crucial to identify modifiable determinants of chronic conditions.

Chronic Conditions and Psychological Resources

Psychological resources are a notable determinant of chronic conditions but have

not received as much attention as lifestyle-related determinants. Psychological resources include inner abilities, strengths, skills and beliefs that influence how individuals manage challenging life events and are often inter-correlated and cluster together synergistically (Hobfoll, 2002; Taylor & Stanton, 2007). Psychological resources are associated with a lower risk of morbidity (Chida & Steptoe, 2008) and mortality (Pressman & Cohen, 2005), and have a positive influence on several health outcomes such as cardiovascular diseases (Cohen, Bavishi, & Rozanski, 2016), depression, and type 2 diabetes (Taylor & Broffman, 2011). An integrated resource theory suggests that psychological resources tend to work in tandem, and possession of a strong psychological resource reservoir is crucial in promoting and maintaining physical and mental health (Hobfoll, 2002).

Several psychological resources have particularly positive effects on chronic conditions. In previous studies, optimism and self-esteem were protective against coronary heart disease and depression (Lundgren, Garvin, Jonasson, Andersson, & Kristenson, 2015; Taylor & Broffman, 2011). Positive affect was associated with reduced morbidity and physical symptoms (Pressman & Cohen, 2005), and a low level of self-acceptance was related to depression and anxiety (Ryff, Singer, & Love, 2004; Taylor & Broffman, 2011). Purpose in life had an inverse association with cardiovascular conditions, and life satisfaction was linked with lowered risk of cancer, stroke, and type 2 diabetes (Cohen et al., 2016; Feller et al., 2013). Positive relations with others and environmental mastery were associated with fewer chronic conditions and health symptoms (Ryff, Radler, & Friedman, 2015).

Mediators Linking Psychological Resources to Chronic Conditions

Emerging research suggests two potential mechanisms by which psychological resources have beneficial effects on chronic conditions: 1) physiological stress regulatory systems (i.e., allostatic load), and 2) health behaviors. Greater activation of stress regulatory systems and engagement in unhealthy behaviors predispose individuals to chronic conditions (Christensen & Antoni, 2008; Salleh, 2008). Psychological resources help individuals adapt to stressful events more effectively through a positive reappraisal and may decrease the negative effects of stress by reducing the activation of stress regulatory systems (Taylor, Kemeny, Reed, Bower, & Gruenewald, 2000; Wiley, Bei, Bower, & Stanton, 2017). Psychological resources may also directly facilitate health-promoting behaviors such as regular exercise and prevent harmful coping behaviors such as substance abuse (Taylor et al., 2000; Taylor & Broffman, 2011). Thus, physiological stress regulatory systems and health behaviors may play a mediating role in the association between psychological resources and chronic conditions.

Allostatic Load as a Mediator

Allostatic load is wear-and-tear on the body representing cumulative physiological dysregulations in multiple systems (e.g., cardiovascular, metabolic, immune), eventually leading to chronic conditions, morbidity, and mortality (Beckie, 2012). Allostatic load is driven by prolonged activation of stress regulatory systems (primarily the sympathetic adrenal medullary and hypothalamic pituitary adrenal), resulting from chronic exposure to stress and adversity over the life span (Wiley et al., 2017). Greater activation of these stress regulatory systems leads to higher allostatic load, which contributes to cardiovascular diseases, metabolic disorder (Danese & McEwen,

2012; Taylor, Lerner, Sherman, Sage, & McDowell, 2003), mortality and declined physical functioning (Wiley et al., 2017).

Psychological resources may decrease the magnitude of reactivity to stress by promoting a positive reframing and problem-solving approach towards stressful situations, leading to less activation of stress regulatory systems and lower allostatic load (Taylor & Broffman, 2011). When faced with adversity, individuals with more psychological resources show less severe physiological responses, such as lower heart rate, lower blood pressure, and lower cortisol levels (Creswell et al., 2005; Taylor & Broffman, 2011). Downregulation of these stress responses over time results in lower allostatic load. One study found that psychological resources such as self-acceptance, purpose in life, positive relations with others, and environmental mastery were significantly associated with lower allostatic load (Johansson, Huang, & Lindfors, 2007). Given that allostatic load is positively associated with chronic conditions and is decreased by psychological resources, allostatic load is hypothesized to play a mediating role between psychological resources and chronic conditions.

Health Behaviors as a Mediator

Health behaviors are a major determinant of chronic conditions (Fine, Philogene, Gramling, Coups, & Sinha, 2004). Engagement in unhealthy behaviors increases the risk of developing cardiovascular disease, type 2 diabetes, cancer, obesity and hypertension (Alvarez & Ayas, 2004; Cappuccio, D'Elia, Strazzullo, & Miller, 2010; U.S. Department of Health and Human Services, 2014). A mounting body of evidence demonstrated that engagement in five key health-promoting behaviors—not smoking, regular exercise,

adequate sleep, healthy eating, moderate alcohol intake— is associated with a significant decrease in morbidity and mortality due to chronic diseases (Matheson, King, & Everett, 2012; Liu et al., 2016).

Psychological resources may directly promote healthy behaviors. Studies found that individuals with more psychological resources are more likely to engage in health-promoting behaviors (Diener & Chan, 2011; Taylor et al., 2000; Taylor & Broffman, 2011). One study found that a high level of life satisfaction was related to not smoking, physical exercise, and consuming a healthier diet (Grant, Wardle, & Steptoe, 2009). Psychological resources may prevent maladaptive coping behaviors, such as smoking and overeating, by helping individuals adopt adaptive coping strategies when faced with adversity (Conversano et al., 2010; O'Neal, Lucier-Greer, Mancini, Ferraro, & Ross, 2016; Taylor et al., 2000; Taylor & Broffman, 2011; Wiley, 2015). Given that health behaviors are negatively associated with chronic conditions and are positively influenced by psychological resources, health behaviors are hypothesized to play a mediating role between psychological resources and chronic conditions.

Current Study

Prior research has investigated a positive role of psychological resources on several health outcomes including chronic conditions. However, there is a dearth of empirical research examining conceptual mediators linking psychological resources to chronic conditions. To our knowledge, no study has tested the mediation effects between psychological resources and chronic conditions via allostatic load and health behaviors. Therefore, the purpose of this study is to investigate the longitudinal effects of

psychological resources on chronic conditions, and the mediating role of allostatic load and health behaviors. We hypothesize the following (Figure 1):

H1: Psychological resources are negatively associated with the prevalence of chronic conditions later in life.

H2: Allostatic load mediates the negative association between psychological resources and the prevalence of chronic conditions.

H3: Health behaviors mediate the negative association between psychological resources and the prevalence of chronic conditions.

[Wave 2: 2004-2006] [Wave 2-1: 2004-2009] [Wave 3: 2013-2014]

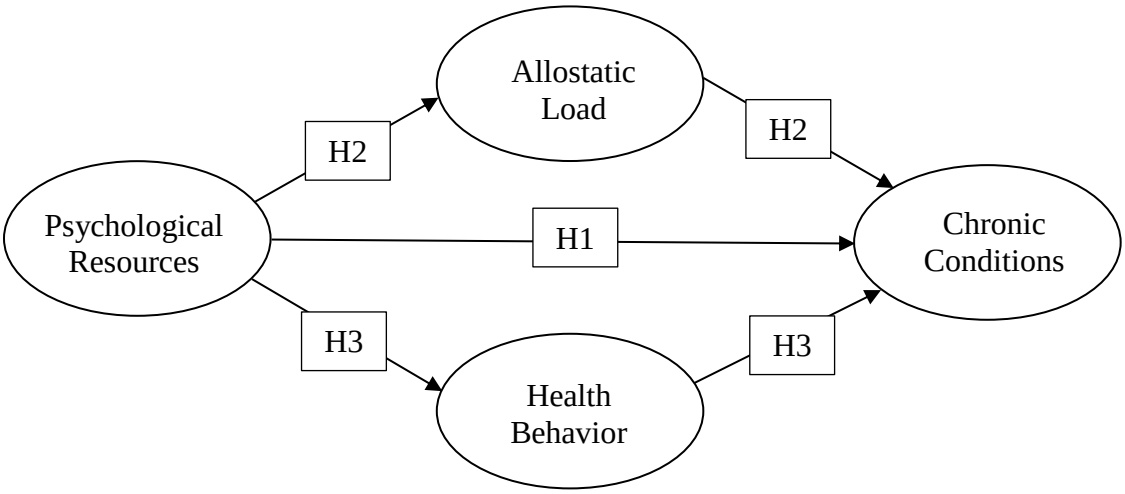

Figure 1. Hypothesized model of the relationship between psychological resources and chronic conditions.

Method

Sample

The present study used data from the Midlife in the United States (MIDUS) cohort, a national longitudinal study of health and well-being in the United States. The initial Wave of data (MIDUS 1) was collected in 1995-1996 to investigate the role of behavioral/psychosocial factors on health and well-being. The original cohort was followed longitudinally and the second Wave of data (MIDUS 2) was collected in 2004-2006. Participants were recruited using random digit dialing and were English-speaking, non-institutionalized adults aged 25 to 74 living in the United States. Surveys consisted of a phone interview and self-administered questionnaires about psychosocial, physical and mental health. Participants who completed MIDUS 2 were eligible to participate in a Biomarker project and visited one of three General Clinical Research Centers (Washington, D.C., Los Angeles, CA, and Madison, WI) for a two-day biomedical data collection during 2004-2009 (Love, Seeman, Weinstein, & Ryff, 2010). Detailed information about sampling procedures and retention rates of the Biomarker project are available elsewhere (Radler & Ryff, 2010). The third Wave of data (MIDUS 3) was collected in 2013-2014.

This study's analysis is based on a subsample of individuals aged 34 to 84 (n = 850) who participated in the MIDUS 2 survey (Wave 2), the Biomarker project (Wave 2-1), and the MIDUS 3 survey (Wave 3). The subsample of participants was not significantly different from the larger MIDUS cohort on most sociodemographic characteristics (age, sex, race, marital status, income) and health characteristics (chronic

conditions, subjective health, exercise, alcohol use), although they were significantly more likely to have a college degree and less likely to smoke (Love et al., 2010).

Measures

Demographic Measures

Demographic variables from Wave 2 were examined and included in the analysis as control variables. Demographic factors include age, sex, race, and education (Table 1).

Table1. Descriptive Statistics of Participant Demographics

Demographics	N	Mean or % (SD)
Age	850	54.73 (11.02)
Sex (% female)	474	55.8%
Race		
White	791	93.1%
Black	21	2.5%
Other	38	4.4%
Education		
Less than high school	25	2.9%
High school diploma	175	20.6%
Some college	179	21.1%
College degree	266	31.2%
Graduate school and above	205	24.1%

Psychological Resources measures

Psychological resources were measured at Wave 2 with eight scales: the three-item Life Orientation Test-Revised scale, a measure of dispositional optimism (Scheier & Carver, 1985); the seven-item Self-Esteem Scale (Rosenberg, 1965); the five-item Life Satisfaction scale (Prenda & Lachman, 2001); the six-item Positive Affect scale (Mroczek & Kolarz, 1998); the seven-item Purpose in Life scale; the seven-item Self-

Acceptance scale; the seven-item Positive Relations with Others scale; and the seven-item Environmental Mastery scale (Ryff & Keyes, 1995). Based on prior research, these resources have shown protective effects on chronic conditions (Cohen & Pressman, 2006; Lundgren et al., 2015; Ryff et al., 2015, 2004; Taylor & Broffman, 2011).

Previous research suggests that psychological resources commonly coexist, are highly correlated and load on a central psychological resource construct (Cozzarelli, 1993; Hobfoll, 2002; Rini, Dunkel-Schetter, Wadhwa, & Sandman, 1999). Therefore, the eight scales were combined into a single composite variable to represent an individual's overall level of psychological resources. A composite variable gives a more complete picture of the overall level of individuals' psychological resources than examining each indicator separately. Also, a composite measure is considered to provide parsimonious and valid statistical results (Best, 2014). The eight psychological resources showed moderate to high correlations (Table 2).

Supporting the concept of a central psychological resource construct, a principal components analysis suggested that a single factor described the eight psychological resource scales in this study (eigenvalue = 4.9, 61.52 % of scale variance explained; all factor loadings >.68). Thus, confirmatory factor analysis was performed, and the eight psychological resources were combined into a single composite variable (α = .86). Model fit indices of a composite variable suggested a good fit given that comparative fit index (CFI = .988) and Tucker-Lewis index (TLI = .982) values were greater than .95 and the root mean square error of approximation (RMSEA = .055) value was smaller than .06

(Hu & Bentler, 1999). Factor loadings of all eight scales on psychological resources were greater than .60, and the average factor loading was .75.

Table 2. Factors Loadings of Psychological Resources and Bivariate Correlations among Psychological Resources Variables

Psychological Resources	FL	1.	2.	3.	4.	5.	6.	7.
1. Optimism	.64	—						
2. Self-esteem	.85	.54*	—					
3. Positive Affect	.72	.45*	.50*	—				
4. Self-acceptance	.75	.58*	.76*	.54*	—			
5. Purpose in Life	.91	.50*	.63*	.43*	.69*	—		
6. Life Satisfaction	.68	.39*	.46*	.46*	.57*	.42*	—	
7. Positive relations with others	.65	.44*	.50*	.39*	.59*	.54*	.39*	—
8. Environmental mastery	.84	.53*	.73*	.54*	.76*	.62*	.58*	.55*

FL = Factor loadings; Note: * $p < 0.01$.

Allostatic Load Measures

Consistent with previous studies using MIDUS data, allostatic load indicators were measured at Wave 2-1 and included 23 biomarkers from seven physiological systems: 1) cardiovascular system (resting systolic blood pressure, resting diastolic blood pressure, and resting heart rate), 2) lipid metabolism (waist-to-hip ratio, triglycerides, high density lipoprotein cholesterol (HDL), and low density lipoprotein cholesterol (LDL), 3) glucose metabolism (glycosylated hemoglobin (Hb1ac), fasting glucose, and homeostasis model of insulin resistance (HOMA-IR)), 4) inflammatory immune response (C-reactive protein (CRP), Interleukin(IL)-6, fibrinogen, sE-Selectin, and soluble intercellular adhesion molecule-1(sICAM-1)), 5) sympathetic nervous system (urine epinephrine and urine norepinephrine), 6) hypothalamic-pituitary-adrenal system (urine cortisol and blood dehydroepiandrosterone sulfate (DHEA-S)), 7) parasympathetic

nervous system (heart rate variability: standard deviation of R-R intervals (SDRR), root mean square of successive differences (RMSSD), low-frequency spectral power and high-frequency spectral power).

Allostatic load scores were calculated as the sum of the seven physiological systems as previous described (Gruenewald et al., 2012; Wiley, Gruenewald, Karlamangla, & Seeman, 2016) according to the following steps. Each biomarker in the system was given a score of 0 or 1 based on being below or above the high-risk cut point value. These scores were summed and divided by the number of biomarkers in each system. Each system score ranged from 0 to 1. For example, in the cardiovascular disease system, if a participant had two biomarkers falling above the high-risk cut point, the system score for this participant would be 0.67 (two divided by three). System scores were only given for participants with recorded values on at least half of the biomarkers in each system. This method of calculation was repeated for all seven biological systems, and allostatic load scores were only given for participants with values on at least six of the seven systems. Scores for each system were summed to create an allostatic load score ranging from 0 to 7, where higher scores indicated greater allostatic load (Table 3).

Table 3. Descriptive Statistics and High-Risk Cut Point Values for Individual Biomarkers and the Multi-System Allostatic Load Score

System and representative biomarkers	N	M	SD	High-risk cut point
Cardiovascular				
Resting SBP (mmHg)	850	130.82	17.51	≥143.00
Resting DBP (mmHg)	850	75.05	10.29	≥82.00
Resting heart rate (bpm)	849	70.22	11.03	≥77.00
Metabolic – lipids				

Table 3 (continued)

Waist-to-Hip Ratio	849	0.89	0.10	≥0.97
Triglycerides (mg/dL)	845	133.29	80.37	≥160.00
HDL Cholesterol (mg/dL)	845	55.00	17.38	≤41.37
LDL Cholesterol (mg/dL)	845	107.47	35.40	≥128.00
Metabolic – glucose metabolism				
Glycosylated hemoglobin (HbA1c)	840	5.97	0.88	≥6.10
Fasting glucose (mg/dL)	841	100.29	24.42	≥1.05
Insulin resistance (HOMA-IR)	841	3.26	3.54	≥4.05
Inflammation				
CRP (mg/L)	840	2.58	3.77	≥3.18
IL6 (pg/mL)	845	2.59	2.41	≥3.18
Fibrinogen (mg/dL)	840	337.08	80.77	≥390.00
sE-Selectin (ng/MI)	845	41.08	20.95	≥50.58
sICAM-1 (ng/MI)	845	282.51	96.45	≥329.65
Sympathetic Nervous System				
Urine Epinephrine (ug/g creatine)	837	2.00	1.25	≥2.54
Urine Norepinephrine (ug/g	842	27.20	12.45	≥33.33
Hypothalamic Pituitary Adrenal Axis				
Urine Cortisol (ug/g creatine)	842	17.09	27.93	≥21.00
Blood DHEA-S (ug/dL)	849	105.97	76.20	≤51.00
Parasympathetic Nervous System				
SDRR (msec)	795	35.01	17.13	≤23.54
RMSSD	795	21.53	16.92	≤11.83
Low-frequency spectral power	795	424.23	614.32	≤113.96
High-frequency spectral power	795	276.59	716.79	≤54.16
Allostatic load Sum Score	845	1.69	1.01	

Health Behaviors Measures

Health behaviors were measured at Wave 2-1using a health behavior index similar to other studies (e.g. Heinrich & Maddock, 2011). The health behavior index was operationalized as a summary score of engagement in five health behaviors—never

regularly smoked, regular exercise, adequate sleep, low/moderate alcohol intake and healthy eating—using dichotomous variables. A health behavior index was only given for participants with values on at least four of the five health behaviors. In the present study, health-promoting behaviors were defined as never smoked cigarettes regularly, exercising regularly at least 20 minutes three times a week, obtaining 7-9 hours of sleep per night for adults (< 65 years old) and 7-8 hours of sleep for older adults (≥ 65 years old), drinking less than one day a week in the past month, and consuming 3-5 cups of fruits and vegetables a day. A response of yes to each category was coded 1, and scores for each category were summed to create a health behavior index composite variable. Scores ranged from 0 to 5, where higher scores indicated greater engagement in health-promoting behaviors (Table 4).

Chronic Conditions Measures

Chronic conditions were measured at Wave 3 using a chronic condition score similar to other studies (e.g. Bensley, VanEenwyk, & Ossiander, 2011). The chronic conditions score was operationalized as a summary of six chronic conditions—diabetes, hypertension, anxiety/depression, stroke, joint/bone problems, and heart conditions—using dichotomous variables. Participants were asked "In the past twelve months, have you experienced or been treated for any of the following – Diabetes or high blood sugar? High blood pressure or hypertension? Anxiety, depression, or some other emotional disorder? Stroke? Arthritis, rheumatism, or other bone or joint diseases? Have you had heart trouble suspected or confirmed by a doctor?" A response of yes to each category was coded 1, and scores for each category were summed to create a composite variable of

chronic conditions score. Scores ranged from 0 to 6, where higher scores indicated a higher number of chronic conditions (Table 4).

Table 4. Descriptive Statistics of Health Behaviors and Chronic Conditions Measures

Type	Variable Description	Range	Mean (SD) or %
Health Behaviors	Regular Exercise	0-1	79%
	Healthy Eating	0-1	20%
	Adequate Sleep	0-1	56%
	Never Regularly Smoked	0-1	55%
	Low/Moderate Alcohol intake	0-1	41%
	Health Behavior Index (Sum)	0-5	2.38 (1.05)
Chronic Conditions	Diabetes	0-1	9%
	Hypertension	0-1	26%
	Anxiety/Depression	0-1	20%
	Stroke	0-1	0.5%
	Joint/bone problems	0-1	26%
	Heart Conditions	0-1	16%
	Chronic Conditions Score (Sum)	0-6	0.97 (1.04)

Statistical Analysis

Path analysis was performed in Mplus version 7.4 (Muthén & Muthén, 1998-2017) to test the fit of the model presented in Figure 1 using full information maximum likelihood estimation, which is a recommended approach to handling missing data (Enders, 2010). Psychological resources (a latent composite variable), health behavior index, allostatic load, and chronic conditions were included in the path model. Two participants were missing heath behavior index scores and five participants were missing allostatic load scores. Skewness and kurtosis of data were between ±1.96, indicating normal distribution of continuous variables (Gravetter & Wallnau, 2016). The model

tested direct and indirect effects of psychological resources at Wave 2 on chronic conditions at Wave 3, and the mediating role of health behaviors and allostatic load at Wave 2-1. Age, sex, race, and education were controlled for on all paths in the model.

Results

The hypothesized model fit indices showed a good model fit ($\chi 2 = 188.86$, df=59, $p < 0.001$, CFI = .971, TLI = .951, RMSEA = .051, and SRMR= .028) based on acceptable fit indices thresholds (CFI > .95, TLI > .95, RMSEA < .06, and SRMR < .08) from Hu and Bentler (1999). Among control variables in the path model, age was positively associated with psychological resources, allostatic load, and chronic conditions. Females and Whites showed a positive correlation with the health behavior index. Educational attainment was negatively associated with allostatic load and positively associated with psychological resources and the health behavior index.

Figure 2 shows standardized coefficients among variables in the model. Psychological resources at Wave 2 were negatively associated with allostatic load at Wave 2-1 (b = -.075, standard error (s.e.) = .035, $p < 0.05$), and allostatic load positively predicted subsequent chronic conditions at Wave 3 (b = .255, s.e. = .033, $p < 0.001$). Psychological resources at Wave 2 were positively associated with the health behavior index at Wave 2-1 (b = .132, s.e. = .035, $p < 0.001$), however, the health behavior index did not significantly predict subsequent chronic conditions at Wave 3 (b = -.061, s.e. = .033, p = .060). As hypothesized, psychological resources at Wave 2 significantly predicted subsequent chronic conditions at Wave 3 (b = -.219, s.e. = .033, $p < 0.001$). Allostatic load at Wave 2-1 partially mediated the association between psychological resources and subsequent chronic conditions, however, the indirect effect was weak (b = -.019, s.e. = .009, $p < 0.05$).

[Wave 2: 2004-2006] [Wave 2-1: 2004-2009] [Wave 3: 2013-2014]

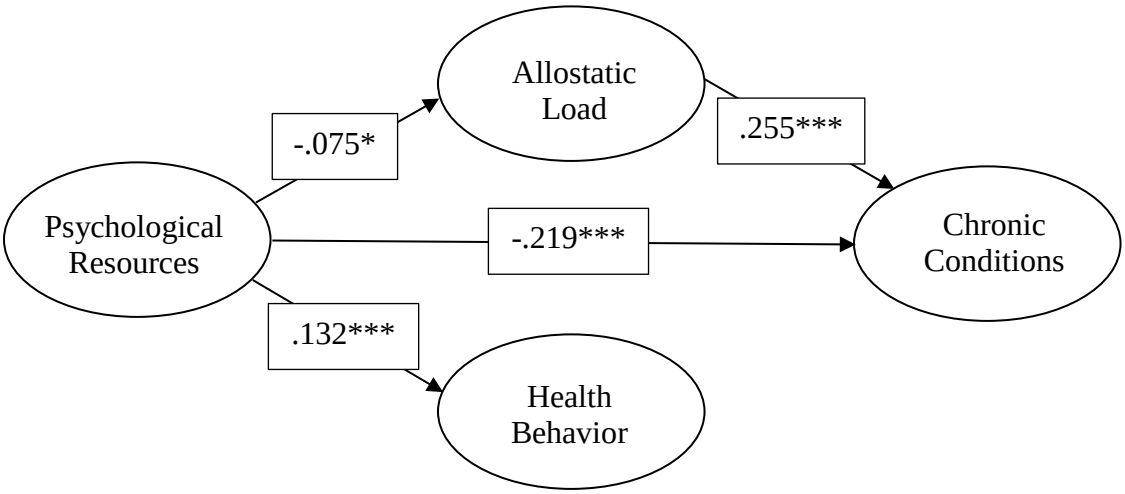

Figure 2. Results from the hypothesized model testing. Standardized coefficients are shown above. Note: *$p < 0.05$; ***$p < 0.001$.

Discussion

Chronic conditions are one of the most important challenges facing public health in the United States. As the population ages, the prevalence of chronic conditions is expected to continue to increase (Gerteis et al., 2014). Given the significant consequences associated with chronic conditions, understanding the protective role of psychological resources on chronic conditions provides valuable insight into promoting health of the population. The present study examined longitudinal effects of psychological resources on chronic conditions, and the mediating role of allostatic load and health behaviors. Findings revealed that individuals with more psychological resources had a lower prevalence of chronic conditions 7-10 years later, and the association was partially mediated by allostatic load but not by health behaviors. These findings contribute to the growing body of research highlighting the benefit of psychological resources on chronic conditions and suggest the need for further exploration of additional mediators.

The study finding of a direct beneficial effect of psychological resources on subsequent chronic conditions is consistent with prior longitudinal research. Life satisfaction was protective against cardiometabolic conditions 8-11 years later (Boehm, Chen, Williams, Ryff, & Kubzansky, 2016), and positive affect was negatively associated with a 10-year incidence of coronary heart disease (Davidson, Mostofsky, & Whang, 2010). Higher self-esteem was predictive of a lower prevalence of depression and anxiety later in life (Sowislo & Orth, 2013). A previous study using the MIDUS cohort found that a psychological resources composite variable, including positive affect and purpose in life, was associated with lower mortality (Chiang, Chen, & Miller, 2018). The present

study builds on the findings of individuals' psychological resources promoting health outcomes by highlighting the synergistic effects of multiple psychological resources on chronic conditions later in life.

Allostatic load was a significant partial mediator between psychological resources and chronic conditions, such that individuals who had more psychological resources showed lower allostatic load, which in turn contributed to a lower prevalence of chronic conditions 7-10 years later. Several longitudinal and cross-sectional studies supported these findings. Optimism was negatively associated with allostatic load (Hernandez et al., 2015), purpose in life was associated with higher HDL cholesterol levels (Ryff et al., 2006), environmental mastery and self-acceptance were related to lower triglycerides (Radler, Rigotti, & Ryff, 2018), purpose in life was negatively linked with glucometabolic markers (Boylan, Tsenkova, Miyamoto, & Ryff, 2017), and positive relations with other had an inverse association with inflammatory markers (Friedman & Ryff, 2012). A meta-analysis supported allostatic load as a major predictor of chronic conditions (Beckie, 2012), and allostatic load was significantly related to hypertension, type 2 diabetes, cardiovascular diseases, and arthritis (Mattei, Demissie, Falcon, Ordovas, & Tucker, 2010). However, given that allostatic load only partially mediated the effect of psychological resources on chronic conditions in the present study, other mediators should be considered.

The health behavior index was not a significant mediator between psychological resources and chronic conditions. However, in line with prior research, individuals who had more psychological resources showed greater engagement in health-promoting

behaviors. Optimism was associated with sustained physical activity (Progovac et al., 2017), positive affect was related to a better sleep habits and a prudent diet, (Steptoe, Dockray, & Wardle, 2009; Steptoe, O'Donnell, Marmot, & Wardle, 2008), and life satisfaction was inversely associated with smoking (Grant et al., 2009). Unexpectedly, health behaviors were not associated with chronic conditions later in life, which did not support our study hypothesis. The non-significant association may be due to the 4-10 year gap between the data collection of health behaviors at Wave 2-1 and chronic conditions at Wave 3. Individuals' health behaviors may change over time, therefore past health behaviors might not fully explain the prevalence of chronic conditions 4-10 years later. Another explanation is that the measurement of the health behavior index used in the present study might not fully capture individuals' health-promoting behaviors that have a positive effect on chronic conditions. One study using 12 different health behaviors including fast food consumption found a significant association between health behaviors and chronic conditions (Heinrich & Maddock, 2011).

This study has several limitations. First, all measures except allostatic load biomarkers were self-reported. It is possible that participants may under/over report their psychological resources, health-promoting behaviors and chronic conditions, which can lead to an inaccurate estimation of study variables. Allostatic load, a physiological variable which has less measurement bias than self-report data, was found to mediate the association between psychological resources and chronic conditions. This result underscores the need for objectively measured data in future research. Second, participants in the MIDUS cohort were not nationally representative, with a limited

number of individuals from racial and ethnic minority groups. Most participants were White and well-educated, so it is difficult to generalize the study findings to a diverse population. Third, this study examined the associations between psychological resources and the prevalence of chronic conditions later in life, not the development of chronic conditions. Therefore, causality cannot be ascertained even though there was a temporal precedence between psychological resources and chronic conditions, which was a strength of the study.

Despite these limitations, the present study provides important contributions to the existing literature and a direction for future research. To our knowledge, this is the first study to investigate associations between psychological resources and chronic conditions, and the mediating role of health behaviors and allostatic load. Psychological resources were a stronger predictor of chronic conditions 7-10 years later than allostatic load and health behaviors. Future research should examine whether the current findings can be generalizable to a diverse population, and explore other mechanisms linking psychological resources to health outcomes. The present study tested a comprehensive model using longitudinal data which provides more compelling evidence for a causal association than cross-sectional data. Future research would benefit from including objective assessments of health behaviors and chronic conditions to establish causality between psychological resources and chronic conditions. This study has public health implications. Psychological resources can help build a strong foundation for physical and mental health across the lifespan. Therefore, public health intervention strategies may

benefit from incorporating a variety of ways to increase psychological resources to prevent diseases and promote the health of the population.

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